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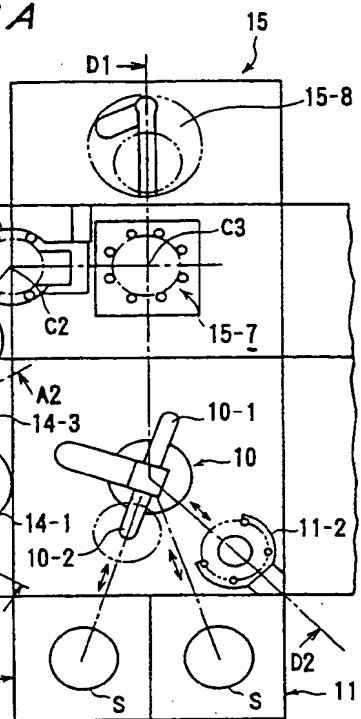
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(57) A polishing apparatus is a cluster type of apparatus having a plurality of units to deal with various works. The polishing apparatus includes a universal transfer robot (10) having at least one arm for transferring a workpiece, a plurality of units disposed around the universal transfer robot and including a loading unit (11) for placing thereon the workpiece (S) to be polished, at least one polishing unit (13,14) for polishing the workpiece, at least one washing unit

(15) for washing the workpiece which has been polished and an unloading unit (12) for placing thereon the cleaned workpiece. The polishing apparatus further includes an exclusive transferring device (13-3,14-3) for transferring the workpiece between two units of the plurality of units adjacent to each other. The universal transfer robot transfers a clean workpiece and the exclusive transferring device transfers a dirty workpiece.



## BACKGROUND OF THE INVENTION

### Field of the Invention:

The present invention relates to a polishing apparatus, and more particularly to a polishing apparatus which has a polishing unit for polishing a workpiece such as a semiconductor wafer, a washing unit for washing the workpiece which has been polished and a universal transfer robot for transferring the workpiece.

### Description of the Related Art:

Recent rapid progress in semiconductor device integration demands smaller and smaller wiring patterns or interconnections and also narrower spaces between interconnections which connect active areas. One of the processes available for forming such interconnection is photolithography. Though the photolithographic process can form interconnections that are at most 0.5  $\mu\text{m}$  wide, it requires that surfaces on which pattern images are to be focused on by a stepper be as flat as possible because the depth of focus of the optical system is relatively small.

It is therefore necessary to make the surfaces of semiconductor wafers flat for photolithography. One customary way of flattening the surfaces of semiconductor wafers is to polish them with a polishing apparatus.

Conventionally, such a polishing apparatus has a single function of polishing a semiconductor wafer. Therefore, in case of washing a semiconductor wafer after polishing, the semiconductor wafer is required to be transferred or transported from the polishing apparatus to a washing apparatus. Further, in case of polishing a semiconductor wafer again under a different condition after polishing, the semiconductor wafer is required to be transferred or transported from one polishing apparatus to another polishing apparatus. In these cases, the semiconductor wafers are manually transferred or transported by a movable container in which they are immersed in water to keep them from drying during transportation. However, since various apparatuses including a polishing apparatus and a washing apparatus are independently installed and the semiconductor wafers are transferred or transported by the movable container containing water therein, it is difficult to install the polishing apparatus, the washing apparatus and the like in a clean room of a semiconductor manufacturing plant and to automate various processes including a polishing process and a washing process completely.

In order to solve the above problems, there has been proposed an apparatus which has a polishing unit and a washing unit housed in a common

housing. Further, if necessary, there is a possibility that a plurality of polishing units are housed in a common housing.

In the polishing apparatus which has a polishing unit and a washing unit, or a plurality of polishing units in a common housing, it is conceivable to construct a cluster type of polishing apparatus which integrates a plurality of units including a polishing unit and a washing unit, as adopted in a semiconductor manufacturing process such as etching or chemical vapor deposit (CVD).

However, in case of constructing a cluster type of polishing apparatus which integrates a plurality of units and incorporates a universal transfer robot at a central position of the units, it is necessary to handle a dirty and wet semiconductor wafer soiled with abrasive slurry or particles generated by polishing operation or a clean and dry semiconductor wafer which is placed on a loading unit or an unloading unit. Therefore, a conventional robot incorporated in a cluster type of a semiconductor manufacturing processing apparatus cannot be used in a cluster type of polishing apparatus because the robot does not have such function that it can handle a clean semiconductor wafer and a dirty semiconductor wafer separately. If the conventional robot is incorporated in the polishing apparatus, a washing process and a drying process of the robot or a robot arm are additionally required, thus lowering throughput.

Further, in case of leaving the robot or the robot arm for a long time as it is, abrasive material or particles generated by polishing operation adheres to the robot or the robot arm, resulting in contaminating subsequent semiconductor wafers or respective units of the polishing apparatus.

## SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide a polishing apparatus which is a cluster type of apparatus having a plurality of units to deal with various works, and has exclusive means for handling a clean semiconductor wafer and exclusive means for handling a dirty semiconductor wafer.

According to the first aspect of the present invention, there is provided a polishing apparatus for polishing a surface of a workpiece and washing the workpiece which has been polished, comprising: a universal transfer robot having at least one arm for transferring the workpiece; a plurality of units disposed around the universal transfer robot and including a loading unit for placing thereon the workpiece to be polished, at least one polishing unit for polishing the workpiece which is transferred from the loading unit, at least one washing unit for washing the workpiece which has been polished

and an unloading unit for placing thereon the cleaned workpiece; and an exclusive transferring device for transferring the workpiece between two units of the plurality of units adjacent to each other; wherein the universal transfer robot transfers a clean workpiece and the exclusive transferring device transfers a dirty workpiece.

According to the first aspect of the present invention, the loading unit, the unloading unit, the polishing unit and the washing unit are disposed around the universal transfer robot. A clean workpiece is picked up from the loading unit by the universal transfer robot, transferred to the polishing unit, and polished by the polishing unit. After a polishing process, a dirty workpiece is transferred from the polishing unit to the washing unit by the exclusive transferring device, and washed by the washing unit. After a washing process, a clean workpiece is transferred from the washing unit to the unloading unit by the universal transfer robot.

According to the second aspect of the present invention, there is provided a polishing apparatus for polishing a surface of a workpiece and washing the workpiece which has been polished, comprising: a universal transfer robot having at least two arms for transferring the workpiece; and a plurality of units disposed around the universal transfer robot and including a loading unit for placing thereon the workpiece to be polished, at least one polishing unit for polishing the workpiece which is transferred from the loading unit, at least one washing unit for washing the workpiece which has been polished and an unloading unit for placing thereon the cleaned workpiece; wherein the universal transfer robot has an arm for exclusively handling a clean workpiece and an arm for exclusively handling a dirty workpiece.

According to the second aspect of the present invention, the loading unit, the unloading unit, the polishing unit and the washing unit are disposed around the universal transfer robot. A clean workpiece is picked up from the loading unit by the arm for exclusively handling a clean workpiece of the universal transfer robot, transferred to the polishing unit, and polished by the polishing unit. After a polishing process, a dirty workpiece is transferred from the polishing unit to the washing unit by the arm for exclusively handling a dirty workpiece of the universal transfer robot, and washed by the washing unit. After a washing process, a clean workpiece is transferred from the washing unit to the unloading unit by the arm for exclusively handling a clean workpiece of the universal transfer robot.

According to the third aspect of the present invention, there is provided a polishing apparatus for polishing a surface of a workpiece and washing the workpiece which has been polished, comprising:

two universal transfer robots each having at least one arm for transferring the workpiece; and a plurality of units disposed around the universal transfer robots and including a loading unit for placing thereon the workpiece to be polished, at least one polishing unit for polishing the workpiece which is transferred from the loading unit, at least one washing unit for washing the workpiece which has been polished and an unloading unit for placing thereon the cleaned workpiece; wherein one of the universal transfer robots transfers a clean workpiece and the other of the universal transfer robots transfers a dirty workpiece.

According to the third aspect of the present invention, the loading unit, the unloading unit, the polishing unit and the washing unit are disposed around the two universal transfer robots. A clean workpiece is picked up from the loading unit by the universal transfer robot for exclusively handling a clean workpiece, transferred to the polishing unit, and polished by the polishing unit. After a polishing process, a dirty workpiece is transferred from the polishing unit to the washing unit by the universal transfer robot for exclusively handling a dirty workpiece, and washed by the washing unit. After a washing process, a clean workpiece is transferred from the washing unit to the unloading unit by the universal transfer robot for exclusively handling a clean workpiece.

#### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic plan view of a polishing apparatus according to an embodiment of the present invention;

FIG. 2A is a schematic plan view showing partially a polishing apparatus according to an embodiment of the present invention;

FIG. 2B is a schematic plan view showing a washing unit in a polishing apparatus according to an embodiment of the present invention;

FIG. 3 is a cross-sectional view taken along line A1-A2 of FIG. 2A;

FIG. 4 is a cross-sectional view taken along line B1-B2 of FIG. 2A;

FIG. 5 is a cross-sectional view taken along line D1-C3-C2-C1 of FIG. 2A;

FIG. 6 is a cross-sectional view taken along line D1-D2 of FIG. 2A;

FIG. 7 is a schematic plan view of a polishing apparatus according to the second embodiment of the present invention;

FIG. 8 is a schematic plan view of a polishing apparatus according to the third embodiment of the present invention;

FIG. 9 is a schematic plan view of a polishing apparatus according to the fourth embodiment of the present invention;

FIG. 10 is a schematic plan view of a polishing apparatus according to the fifth embodiment of the present invention; and

FIG. 11 is a schematic plan view of a polishing apparatus according to the sixth embodiment of the present invention.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A polishing apparatus according to an embodiment of the present invention will be described below with reference to FIG. 1. In the embodiments, description will be made using a semiconductor wafer as a workpiece to be polished. As shown in FIG. 1, a polishing apparatus has a center robot 10 having arms 10-1 and 10-2 at a central part thereof. The center robot 10 constitutes a universal transfer robot. Around the center robot 10 and in the area where the arm 10-1 can access, there are provided a loading unit 11 for placing thereon a semiconductor wafer S to be polished, an unloading unit 12 for placing thereon the semiconductor wafer S which has been polished, polishing units 13 and 14 each for polishing the semiconductor wafer S and a washing unit 15 for washing the semiconductor wafer S.

The polishing unit 13 has a polishing head supporting arm 13-3, a turntable 13-4 and a top ring rotatably provided on the polishing head supporting arm 13-3. The polishing unit 14, has a polishing head supporting arm 14-3, a turntable 14-4 and a top ring rotatably provided on the polishing head supporting arm 14-3. An abrasive cloth is attached to respective upper surfaces of the turntables 13-4 and 14-4. Each of the polishing head supporting arms 13-3 and 14-3 constitutes an exclusive transferring device for transferring the semiconductor wafer S from a loading position 13-1, 14-1 of the polishing unit to the turntable 13-4, 14-4. Further, each of the polishing head supporting arms 13-3 and 14-3 constitutes an exclusive transferring device for transferring the semiconductor wafer S from the polishing unit 13, 14 to the washing unit 15. The polishing apparatus has a table 16 for placing a dressing tool for dressing the abrasive cloth on the turntable 13-4 and a table 17 for placing a dressing tool for dressing the abrasive cloth on the turntable 14-4.

In the polishing apparatus, the semiconductor wafer S to be polished is picked up under vacuum by the arm 10-1 of the center robot 10, reversed to make a surface to be polished downward, and transferred to the loading position 13-1 of the polishing unit 13. The top ring of the polishing head supporting arm 13-3 holds the semiconductor wafer S and presses the semiconductor wafer S against the abrasive cloth attached to the upper surface of

the turntable 13-4. At this time, the turntable 13-4 is rotated, and the top ring is rotated about its own axis and swung on the turntable 13-4 by the polishing head supporting arm 13-3, whereby the semiconductor wafer S is polished.

After a polishing process, the semiconductor wafer S is transferred to a loading position 15-1 of the washing unit 15 by the polishing head supporting arm 13-3. The polishing head supporting arm 13-3 which releases the semiconductor wafer S at the loading position 15-1 chucks a dressing tool 16-1 on the table 16 and presses the dressing tool 16-1 against the abrasive cloth on the turntable 13-4, thereby dressing the abrasive cloth. This dressing work may be performed by an exclusive dressing mechanism.

The semiconductor wafer S which has been transferred to the loading position 14-1 of the polishing unit 14 by the arm 10-1 of the center robot 10 is also held by the top ring of the polishing head supporting arm 14-3 and pressed against the abrasive cloth attached to the upper surface of the turntable 14-4. After a polishing process, the semiconductor wafer S is transferred to a loading position 15-2 of the washing unit 15. Further, the polishing head supporting arm 14-3 which releases the semiconductor wafer S chucks a dressing tool 17-1 on the table 17 and presses the dressing tool 17-1 against the abrasive cloth on the turntable 14-4, thereby dressing the abrasive cloth.

The semiconductor wafer S transferred to the loading position 15-1 or the loading position 15-2 is washed in the washing unit 15, and then transferred to an unloading position 15-3. The cleaned semiconductor wafer S is transferred from the unloading position 15-3 to the unloading unit 12 by the arm 10-2 of the center robot 10. The above entire operations are performed automatically.

Next, the polishing unit 14 and the washing unit 15 will be described in detail with reference to FIGS. 2 through 6. FIGS. 2 through 6 show the first embodiment of the present invention as well as FIG. 1. However, a dressing tool and a table for placing the dressing tool are not provided, but an exclusive dressing mechanism 15-11 is provided.

As shown in FIG. 2, the semiconductor wafer S placed on the loading unit 11 is picked up by the arm 10-1 of the center robot 10, reversed to make a surface to be polished downward by a reversing mechanism 11-2 and transferred to the loading position 14-1 of the polishing unit 14. As shown in FIG. 3, the semiconductor wafer S is held under vacuum by the top ring 14-5 provided at the forward end of the polishing head supporting arm 14-3 and moved above the turntable 14-4. Thereafter, the top ring 14-5 is lowered, and the semiconductor wafer S held by the top ring 14-5 is pressed against the abrasive cloth on the turntable 14-4,

whereby the semiconductor wafer S is polished. Incidentally, the turntable 14-4 is rotated by a motor 14-6 through a timing belt 14-7 (see FIG. 4). As shown in FIG. 5, after a polishing process, the semiconductor wafer S is put into a washing receptacle 15-4 which is standing by at an opening of the loading position 15-2 of the washing unit 15, and washed by clearing solvent. During a washing process, the opening of the loading position 15-2 is closed by a shutter 15-5. The top ring 14-5 which releases the semiconductor wafer S is washed at the loading position by a washing mechanism of the washing unit 15.

After a washing process, the semiconductor wafer S is moved in a direction of (a) and transferred to a reversing mechanism 15-6 by which the semiconductor wafer S is reversed to make a surface which has been polished upward and supplied to a primary washing station 15-7. A primary washing process is carried out using clearing solvent such as pure water at the primary washing station 15-7. Thereafter, the semiconductor wafer S is picked up by a transfer robot 15-8 in the washing unit 15, moved in a direction of arrows b and c and fed to a secondary washing station 15-9. A secondary washing process is carried out using clearing solvent such as pure water at the secondary washing station 15-9.

After the secondary washing process, the semiconductor wafer S is picked up by the arm 10-2 of the center robot 10, moved in a direction of arrows d and e as shown in FIG. 6, and transferred to the unloading unit 12. As shown in FIG. 2, there is provided a dressing mechanism 15-11 for dressing the abrasive cloth on the turntable 14-4. The dressing mechanism 15-11 has a rotating brush 15-12 as shown in FIG. 3.

According to the first embodiment, the polishing apparatus comprises a center robot 10 having arms 10-1 and 10-2 and constituting a universal transfer robot for transferring the semiconductor wafer S to the respective units, a plurality of units disposed around the center robot 10 and including a loading unit 11 for placing thereon the semiconductor wafer S to be polished, an unloading unit 12 for placing thereon the semiconductor wafer S which has been polished, polishing units 13 and 14 each for polishing the semiconductor wafer S and a washing unit 15 for washing the semiconductor wafer S. The polishing apparatus further comprises a polishing head supporting arm 13-3 having a top ring for transferring the semiconductor wafer S between two adjacent units and a polishing head supporting arm 14-3 having a top ring for transferring the semiconductor wafer S between two adjacent units. The center robot 10 handles a clean and dry semiconductor wafer S, and the polishing head supporting arms 13-3 and 14-3 handle a dirty and

wet semiconductor wafer S.

The center robot 10 has the arm 10-1 which is exclusively used for loading the semiconductor wafer to be polished and the arm 10-2 which is exclusively used for unloading the semiconductor wafer which has been polished. This arrangement is preferable for such a case where cleanliness of the semiconductor wafer S transferred from the loading unit 11 is different from that of the semiconductor wafer S transferred to the unloading unit 12.

Next, a polishing apparatus according to the second embodiment of the present invention will be described below with reference to FIG. 7. The parts shown in FIG. 7 which are identical to those of FIG. 1 are denoted by identical reference numerals. A polishing apparatus has a center robot 10 having arms 10-1 and 10-2 at a central part thereof. Around the center robot 10 and in the area where the arm 10-1 can access, there are provided a loading unit 11, an unloading unit 12, polishing units 13 and 14, a washing unit 15, and auxiliary spaces 18 and 19 for installing additional units, in a hexagonal arrangement.

In the auxiliary spaces 18 and 19, for example, a thickness meter for measuring a thickness of the semiconductor wafer is installed. In this case, the semiconductor wafer S is held by the arm 10-1 of the center robot 10 and fed to the thickness meter in the auxiliary space 18. Before a polishing process, a thickness of the semiconductor wafer S is measured by the thickness meter, and then transferred to the loading position 13-1 of the polishing unit 13.

After a polishing process, the semiconductor wafer S is transferred to the washing unit 15 in the same manner as the first embodiment, and washed in the washing unit 15. After a washing process, the semiconductor wafer S is fed to the thickness meter in the auxiliary space 18 by the arm 10-1 of the center robot. After measuring a thickness of the semiconductor wafer S which has been polished, the semiconductor wafer S is transferred to the unloading unit 12 by the arm 10-2 of the center robot 10.

FIG. 8 shows a polishing apparatus according to the third embodiment of the present invention. The parts shown in FIG. 8 which are identical to those of FIG. 1 are denoted by identical reference numerals. Around a center robot 10 having arms 10-1 and 10-2 and in the area where the arm 10-1 can access, there are provided a loading unit 11, an unloading unit 12, two polishing units 13 and 13, a polishing unit 14, a washing unit 15 provided between the polishing units 13 and 13, and a washing unit 15 provided between the polishing unit 14 and the unloading unit 12, in a hexagonal arrangement. This arrangement is preferable for

such a case where a polishing time of the polishing unit 13 requires twice as much as that of the polishing unit 14.

In this case, the transfer of the semiconductor wafer S from the polishing units 13 and 13 to the washing unit 15 and the transfer of the semiconductor wafer S from the polishing unit 14 to the washing unit 15 are performed by not the center robot 10 but another transfer means such as the polishing head supporting arms 13-3 and 14-3. However, the loading of the semiconductor wafer to the polishing units 13, 13 and 14 and the picking of the semiconductor wafer from the washing units 15 and 15 are performed by the arms 10-1 and 10-2 of the center robot 10. That is, the center robot 10 does not handle the semiconductor wafer polished by the polishing units 13, 13 and 14 so that the arms 10-1 and 10-2 of the center robot 10 are not contaminated by the semiconductor wafer which has been polished and to which abrasive slurry adheres.

FIG. 9 shows a polishing apparatus according to the fourth embodiment of the present invention. The parts shown in FIG. 9 which are identical to those of FIG. 1 are denoted by identical reference numerals. The polishing apparatus is provided with a center robot 10 having only an arm 10-1. In case of providing only the arm 10-1, exclusive transferring devices are provided between the polishing units 13 and 14, and between the polishing units 13, 14 and the washing unit 15. This system is applicable to such a case where cleanliness of the semiconductor wafer which is picked up from the loading unit 11 is substantially the same as that of the semiconductor wafer which is transferred to the unloading unit 12.

FIG. 10 shows a polishing apparatus according to the fifth embodiment of the present invention. The parts shown in FIG. 10 which are identical to those of FIG. 1 are denoted by identical reference numerals. Around a center robot 10 having arms and in the area where the arms can access, there are provided a loading unit 11, four polishing units 13, 14, 21 and 22, and a washing unit 15, in a hexagonal arrangement. An unloading unit 12 is disposed at the end of the washing unit 15. Further, a storage 23 is disposed adjacent to the loading unit 11 and the unloading unit 12. An automatic guided vehicle 24 is used to take the semiconductor wafer S, which has been polished, out of the storage 23 and to convey the semiconductor wafer to be polished into the storage 23.

Loading of the semiconductor wafer S to the polishing units 13, 14, 21 and 22 and the washing unit 15 and picking the semiconductor wafer S from the loading unit 11 and the polishing units 13, 14, 21 and 22 are entirely carried out by the center robot 10. Further, the transfer of the semiconductor

wafer from the washing unit 15 to the unloading unit 12 is carried out by the center robot 10. The center robot 10 is provided with an arm for exclusively handling a clean semiconductor wafer (hereinafter referred as clean wafer handling arm) and an arm for exclusively handling a dirty semiconductor wafer (hereinafter referred as dirty wafer handling arm). The transfer of the semiconductor wafer from the loading unit 11 to one of the polishing units 13, 14, 21 and 22 and the transfer of the semiconductor wafer from the washing unit 15 to the unloading unit 12 are carried out by the clean wafer handling arm, and the transfer of the semiconductor wafer between the polishing units 13, 14, 21 and 22 and the transfer of the semiconductor wafer from one of the polishing units 13, 14, 21 and 22 to the washing unit 15 are carried out by the dirty wafer handling arm. For example, in case of using the center robot 10 of FIG. 1, the arm 10-1 serves as the clean wafer handling arm and the arm 10-2 serves as the dirty wafer handling arm. This structure prevents the semiconductor wafer from being contaminated as much as possible.

According to the fifth embodiment, the polishing apparatus comprises a center robot 10 having arms 10-1 and 10-2 and constituting a universal transfer robot for transferring a semiconductor wafer S to the respective units, a plurality of units disposed around the center robot 10 and including a loading unit 11 for placing thereon the semiconductor wafer S to be polished, an unloading unit 12 for placing thereon the semiconductor wafer S which has been polished, polishing units 13, 14, 21 and 22 each for polishing the semiconductor wafer S and a washing unit 15 for washing the semiconductor wafer S. The center robot 10 is provided with an arm for exclusively handling a clean semiconductor wafer and an arm for exclusively handling a dirty semiconductor wafer. The arm for exclusively handling a dirty semiconductor wafer is washed by a washing mechanism provided in the washing unit 15 after handling the dirty semiconductor wafer.

FIG. 11 shows a polishing apparatus according to the sixth embodiment of the present invention. The parts shown in FIG. 11 which are identical to those of FIG. 1 are denoted by identical reference numerals. In this embodiment, the polishing apparatus comprises a center robot 10A for exclusively handling a clean semiconductor wafer and a center robot 10B for exclusively handling a dirty semiconductor wafer. Further, the polishing apparatus comprises two polishing units 13, 14 and a washing unit 15.

With the above structure, a semiconductor wafer S is picked up from a loading unit 11 by the center robot 10A, and transferred to a loading position 13-1 of the polishing unit 13. After a

polishing process, the semiconductor wafer S is picked up from the polishing unit 13 by the center robot 10B and transferred to a loading position 15-1 of the washing unit 15. After a washing process, the semiconductor wafer S is picked up from a loading position 15-3 of the washing unit 15 by the center robot 10A and transferred to an unloading unit 12. By the above manner, a polishing process and a washing process are carried out. A polishing process by the polishing unit 14 is carried out in the same manner as the above.

According to the polishing apparatus of this embodiment, the semiconductor wafers S are polished simultaneously or with a certain timelag by the polishing units 13 and 14, and each of the semiconductor wafers S polished by the polishing units 13 and 14 is washed by the washing unit 15. That is, it is possible to deal with two semiconductor wafers by one washing unit relative to two polishing units. Especially, in the case where processing interval of the semiconductor wafer by the washing unit, i.e. time interval from a washing process of the preceding semiconductor wafer to a washing process of the subsequent semiconductor wafer is sufficiently shorter than the time required to polish semiconductor wafers, there is no waiting time in the polishing process by restriction caused by the washing process, thus preventing processing speed from lowering and enabling the total system to become compact in size.

Further, the polishing units 13 and 14 can be set to polish a semiconductor wafer under a different condition, and selected in accordance with properties of the semiconductor wafer. Furthermore, the semiconductor wafer can be polished by the polishing unit 13, washed by the washing unit 15, and then polished by the polishing unit 14. Thereafter, the semiconductor wafer S can be washed by the washing unit 15. That is, the semiconductor wafer can be polished twice. Incidentally, the polishing apparatus has auxiliary spaces 18 and 19 as shown in FIG. 11.

According to the sixth embodiment, the polishing apparatus comprises two center robots 10A, 10B each constituting a universal transfer robot for transferring a semiconductor wafer S to the respective units, a plurality of units disposed around the center robots 10A and 10B and including a loading unit 11 for placing thereon the semiconductor wafer S to be polished, an unloading unit 12 for placing thereon the semiconductor wafer S which has been polished, polishing units 13 and 14 each for polishing the semiconductor wafer S and a washing unit 15 for washing the semiconductor wafer S which has been polished. The center robot 10A handles only a clean semiconductor wafer, and the center robot 10B handles only a dirty semiconductor wafer. The center robot 10B is washed by a washing

mechanism provided in the washing unit 15 after handling the dirty semiconductor wafer.

According to the polishing apparatus of the first through sixth embodiments, since at least one polishing unit for performing chemical mechanical polishing and at least one washing unit are disposed around a center robot, the whole system becomes compact in size. Therefore, by providing a housing to cover the whole system and an exhaust duct, the polishing apparatus can be installed in the clean room without lowering cleanliness of the clean room. Further, saving of installation space of the polishing apparatus in the clean room can be achieved.

In the above embodiments, although the loading unit 11 and the unloading unit 12 are separately provided, the loading unit 11 and the unloading unit 12 may be integrally provided. For example, in the case where a semiconductor wafer is picked up from a basket containing semiconductor wafers and put into the same basket after a polishing process and a washing process, the loading unit and the unloading unit are integrally formed.

According to the present invention, a cluster type of polishing apparatus which integrates a plurality of units including a polishing unit and a washing unit and uses a universal transfer robot can be constructed. Thus, in the polishing apparatus which performs a series of processes including a polishing process and a washing process, saving of installation space and improvement of processing speed can be achieved, and a plurality of units including at least one polishing unit and at least one washing unit can be efficiently combined. To be more specific, in the case where polishing time is longer than time interval of washing process, it is possible to deal with a plurality of semiconductor wafers by one washing unit relative to a plurality of polishing units. On the contrary, in the case where time interval of washing process is longer than polishing time, it is possible to deal with a plurality of semiconductor wafers by one polishing unit relative to a plurality of washing units. Further, according to the present invention, one or more polishing processes and one or more washing processes can be fully automated and change of processes can be easily effected.

Furthermore, according to the present invention, since exclusive means for handling a clean semiconductor wafer and exclusive means for handling a dirty semiconductor wafer are separately provided, contamination of subsequent semiconductor wafers or respective units of the polishing apparatus caused by the dirty semiconductor wafer can be prevented.

It should be noted that the objects and advantages of the invention may be attained by means of any compatible combination(s) particularly pointed out



in the items of the following summary of the invention and the appended claims.

The invention may be summarized as follows:

1 A polishing apparatus for polishing a surface of a workpiece and washing the workpiece which has been polished, comprising:

a universal transfer robot having at least one arm for transferring the workpiece;

a plurality of units disposed around said universal transfer robot and including a loading unit for placing thereon the workpiece to be polished, at least one polishing unit for polishing the workpiece which is transferred from said loading unit, at least one washing unit for washing the workpiece which has been polished and an unloading unit for placing thereon the cleaned workpiece; and

an exclusive transferring device for transferring the workpiece between two units of said plurality of units adjacent to each other;

wherein said universal transfer robot transfers a clean workpiece and said exclusive transferring device transfers a dirty workpiece.

2. The polishing apparatus according to 1, further comprising a storage disposed adjacent to at least one of said loading unit and said unloading unit for storing workpieces to be polished and workpieces which have been polished.

3. The polishing apparatus according to 1, further comprising a washing mechanism for washing said exclusive transferring device.

4. A polishing apparatus for polishing a surface of a workpiece and washing the workpiece which has been polished, comprising:

a center robot having at least one arm for transferring the workpiece;

a plurality of units disposed around said center robot and including a loading unit for placing thereon the workpiece to be polished, at least one polishing unit for polishing the workpiece which is transferred from said loading unit, at least one washing unit for washing the workpiece which has been polished and an unloading unit for placing thereon the cleaned workpiece;

wherein said polishing unit comprises a loading position for placing thereon a clean workpiece which is transferred from said loading unit by said center robot, a turntable provided adjacent to said loading position, a polishing head supporting arm for transferring the workpiece from said loading position onto said turntable and a top ring for holding the workpiece and pressing the workpiece against said turntable;

wherein said washing unit comprises a load-

ing position for placing thereon a dirty workpiece which has been polished and is transferred from said turntable by said polishing head supporting arm, a primary washing station for performing a primary washing process of the workpiece and a secondary washing station for performing a secondary washing process of the workpiece, and an unloading position for placing thereon a clean workpiece which has been washed at said primary and secondary washing stations; and

wherein said center robot transfers said clean workpiece from said unloading position of said washing unit to said unloading unit.

5. A polishing apparatus for polishing a surface of a workpiece and washing the workpiece which has been polished, comprising:

a universal transfer robot having at least two arms for transferring the workpiece; and

a plurality of units disposed around said universal transfer robot and including a loading unit for placing thereon the workpiece to be polished, at least one polishing unit for polishing the workpiece which is transferred from said loading unit, at least one washing unit for washing the workpiece which has been polished and an unloading unit for placing thereon the cleaned workpiece;

wherein said universal transfer robot has an arm for exclusively handling a clean workpiece and an arm for exclusively handling a dirty workpiece.

6. The polishing apparatus according to 5, further comprising a storage disposed adjacent to at least one of said loading unit and said unloading unit for storing workpieces to be polished and workpieces which have been polished.

7. The polishing apparatus according to 5, further comprising a washing mechanism for washing said arm for exclusively handling a dirty workpiece.

8. A polishing apparatus for polishing a surface of a workpiece and washing the workpiece which has been polished, comprising:

a center robot having at least two arms, one of which is exclusively used for transferring a clean workpiece, the other of which is exclusively used for transferring a dirty workpiece;

a plurality of units disposed around said center robot and including a loading unit for placing thereon the workpiece to be polished, at least one polishing unit for polishing the workpiece which is transferred from said loading unit, at least one washing unit for washing the workpiece which has been polished and an unloading unit for placing thereon the cleaned workpiece;

wherein said polishing unit comprises a

loading position for placing thereon a clean workpiece which is transferred from said loading unit by said one arm of said center robot, a turntable provided adjacent to said loading position and a top ring for holding the workpiece and pressing the workpiece against said turntable;

wherein said washing unit comprises a loading position for placing thereon a dirty workpiece which has been polished and is transferred from said turntable by said the other arm of said center robot, a primary washing station for performing a primary washing process of the workpiece and a secondary washing station for performing a secondary washing process of the workpiece, and an unloading position for placing thereon a clean workpiece which has been washed at said primary and secondary washing stations; and

wherein said one arm of said center robot transfers said clean workpiece from said unloading position of said washing unit to said unloading unit.

9. A polishing apparatus for polishing a surface of a workpiece and washing the workpiece which has been polished, comprising:

two universal transfer robots each having at least one arm for transferring the workpiece; and

a plurality of units disposed around said universal transfer robots and including a loading unit for placing thereon the workpiece to be polished, at least one polishing unit for polishing the workpiece which is transferred from said loading unit, at least one washing unit for washing the workpiece which has been polished and an unloading unit for placing thereon the cleaned workpiece;

wherein one of said universal transfer robots transfers a clean workpiece and the other of said universal transfer robots transfers a dirty workpiece.

10. The polishing apparatus according to 9, further comprising a storage disposed adjacent to at least one of said loading unit and said unloading unit for storing workpieces to be polished and workpieces which have been polished.

11. The polishing apparatus according to 9, further comprising a washing mechanism for washing said universal transfer robot which transfers said dirty workpiece.

12. A polishing apparatus for polishing a surface of a workpiece and washing the workpiece which has been polished, comprising:

two center robots each having at least one arm, one of said center robots being exclusively used for transferring a clean workpiece, the other of said center robots being exclusively used for transferring a dirty workpiece;

a plurality of units disposed around said center robots and including a loading unit for placing thereon the workpiece to be polished, at least one polishing unit for polishing the workpiece which is transferred from said loading unit, at least one washing unit for washing the workpiece which has been polished and an unloading unit for placing thereon the cleaned workpiece;

wherein said polishing unit comprises a loading position for placing thereon a clean workpiece which is transferred from said loading unit by said one of said center robots, a turntable provided adjacent to said loading position and a top ring for holding the workpiece and pressing the workpiece against said turntable;

wherein said washing unit comprises a loading position for placing thereon a dirty workpiece which has been polished and is transferred from said turntable by said the other of said center robots, a primary washing station for performing a primary washing process of the workpiece and a secondary washing station for performing a secondary washing process of the workpiece, and an unloading position for placing thereon a clean workpiece which has been washed at said primary and secondary washing stations; and

wherein said one of said center robots transfers said clean workpiece from said unloading position of said washing unit to said unloading unit.

## Claims

1. A polishing apparatus for polishing a surface of a workpiece and washing the workpiece which has been polished, comprising:

a universal transfer robot having at least one arm for transferring the workpiece;

a plurality of units disposed around said universal transfer robot and including a loading unit for placing thereon the workpiece to be polished, at least one polishing unit for polishing the workpiece which is transferred from said loading unit, at least one washing unit for washing the workpiece which has been polished and an unloading unit for placing thereon the cleaned workpiece; and

an exclusive transferring device for transferring the workpiece between two units of said plurality of units adjacent to each other;

wherein said universal transfer robot transfers a clean workpiece and said exclusive transferring device transfers a dirty workpiece.

2. The polishing apparatus according to claim 1, further comprising a storage disposed adjacent to at least one of said loading unit and said

unloading unit for storing workpieces to be polished and workpieces which have been polished.

3. The polishing apparatus according to claim 1, further comprising a washing mechanism for washing said exclusive transferring device. 5
4. A polishing apparatus for polishing a surface of a workpiece and washing the workpiece which has been polished, comprising: 10
  - a center robot having at least one arm for transferring the workpiece;
  - a plurality of units disposed around said center robot and including a loading unit for placing thereon the workpiece to be polished, at least one polishing unit for polishing the workpiece which is transferred from said loading unit, at least one washing unit for washing the workpiece which has been polished and an unloading unit for placing thereon the cleaned workpiece; 15
  - wherein said polishing unit comprises a loading position for placing thereon a clean workpiece which is transferred from said loading unit by said center robot, a turntable provided adjacent to said loading position, a polishing head supporting arm for transferring the workpiece from said loading position onto said turntable and a top ring for holding the workpiece and pressing the workpiece against said turntable; 20
  - wherein said washing unit comprises a loading position for placing thereon a dirty workpiece which has been polished and is transferred from said turntable by said polishing head supporting arm, a primary washing station for performing a primary washing process of the workpiece and a secondary washing station for performing a secondary washing process of the workpiece, and an unloading position for placing thereon a clean workpiece which has been washed at said primary and secondary washing stations; and 25
  - wherein said center robot transfers said clean workpiece from said unloading position of said washing unit to said unloading unit. 30
5. A polishing apparatus for polishing a surface of a workpiece and washing the workpiece which has been polished, comprising: 35
  - a universal transfer robot having at least two arms for transferring the workpiece; and
  - a plurality of units disposed around said universal transfer robot and including a loading unit for placing thereon the workpiece to be polished, at least one polishing unit for polishing the workpiece which is transferred from 40

said loading unit, at least one washing unit for washing the workpiece which has been polished and an unloading unit for placing thereon the cleaned workpiece;

wherein said universal transfer robot has an arm for exclusively handling a clean workpiece and an arm for exclusively handling a dirty workpiece.

6. The polishing apparatus according to claim 5, further comprising a storage disposed adjacent to at least one of said loading unit and said unloading unit for storing workpieces to be polished and workpieces which have been polished. 45
7. The polishing apparatus according to claim 5, further comprising a washing mechanism for washing said arm for exclusively handling a dirty workpiece. 50
8. A polishing apparatus for polishing a surface of a workpiece and washing the workpiece which has been polished, comprising: 55
  - a center robot having at least two arms, one of which is exclusively used for transferring a clean workpiece, the other of which is exclusively used for transferring a dirty workpiece;
  - a plurality of units disposed around said center robot and including a loading unit for placing thereon the workpiece to be polished, at least one polishing unit for polishing the workpiece which is transferred from said loading unit, at least one washing unit for washing the workpiece which has been polished and an unloading unit for placing thereon the cleaned workpiece;
  - wherein said polishing unit comprises a loading position for placing thereon a clean workpiece which is transferred from said loading unit by said one arm of said center robot, a turntable provided adjacent to said loading position and a top ring for holding the workpiece and pressing the workpiece against said turntable;
  - wherein said washing unit comprises a loading position for placing thereon a dirty workpiece which has been polished and is transferred from said turntable by said the other arm of said center robot, a primary washing station for performing a primary washing process of the workpiece and a secondary washing station for performing a secondary washing process of the workpiece, and an unloading position for placing thereon a clean workpiece which has been washed at said primary and secondary washing stations; and

wherein said one arm of said center robot transfers said clean workpiece from said unloading position of said washing unit to said unloading unit.

9. A polishing apparatus for polishing a surface of a workpiece and washing the workpiece which has been polished, comprising:

two universal transfer robots each having at least one arm for transferring the workpiece; and

a plurality of units disposed around said universal transfer robots and including a loading unit for placing thereon the workpiece to be polished, at least one polishing unit for polishing the workpiece which is transferred from said loading unit, at least one washing unit for washing the workpiece which has been polished and an unloading unit for placing thereon the cleaned workpiece.

wherein one of said universal transfer robots transfers a clean workpiece and the other of said universal transfer robots transfers a dirty workpiece.

10. The polishing apparatus according to claim 9, further comprising a storage disposed adjacent to at least one of said loading unit and said unloading unit for storing workpieces to be polished and workpieces which have been polished, and, preferably, further comprising a washing mechanism for washing said universal transfer robot which transfers said dirty workpiece.

11. A polishing apparatus for polishing a surface of a workpiece and washing the workpiece which has been polished, comprising:

two center robots each having at least one arm, one of said center robots being exclusively used for transferring a clean workpiece, the other of said center robots being exclusively used for transferring a dirty workpiece;

a plurality of units disposed around said center robots and including a loading unit for placing thereon the workpiece to be polished, at least one polishing unit for polishing the workpiece which is transferred from said loading unit, at least one washing unit for washing the workpiece which has been polished and an unloading unit for placing thereon the cleaned workpiece;

wherein said polishing unit comprises a loading position for placing thereon a clean workpiece which is transferred from said loading unit by said one of said center robots, a turntable provided adjacent to said loading position and a top ring for holding the workpiece

and pressing the workpiece against said turntable;

wherein said washing unit comprises a loading position for placing thereon a dirty workpiece which has been polished and is transferred from said turntable by said the other of said center robots, a primary washing station for performing a primary washing process of the workpiece and a secondary washing station for performing a secondary washing process of the workpiece, and an unloading position for placing thereon a clean workpiece which has been washed at said primary and secondary washing stations; and

wherein said one of said center robots transfers said clean workpiece from said unloading position of said washing unit to said unloading unit.

12. A polishing apparatus for polishing a surface of a workpiece comprising:

a transfer means having at least one arm for transferring the workpiece;

a plurality of units; and

a transferring device for transferring the workpiece between units of said plurality of units.



FIG. 2B

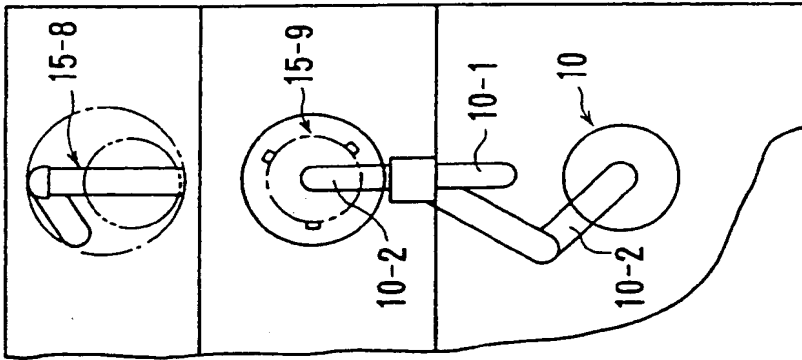
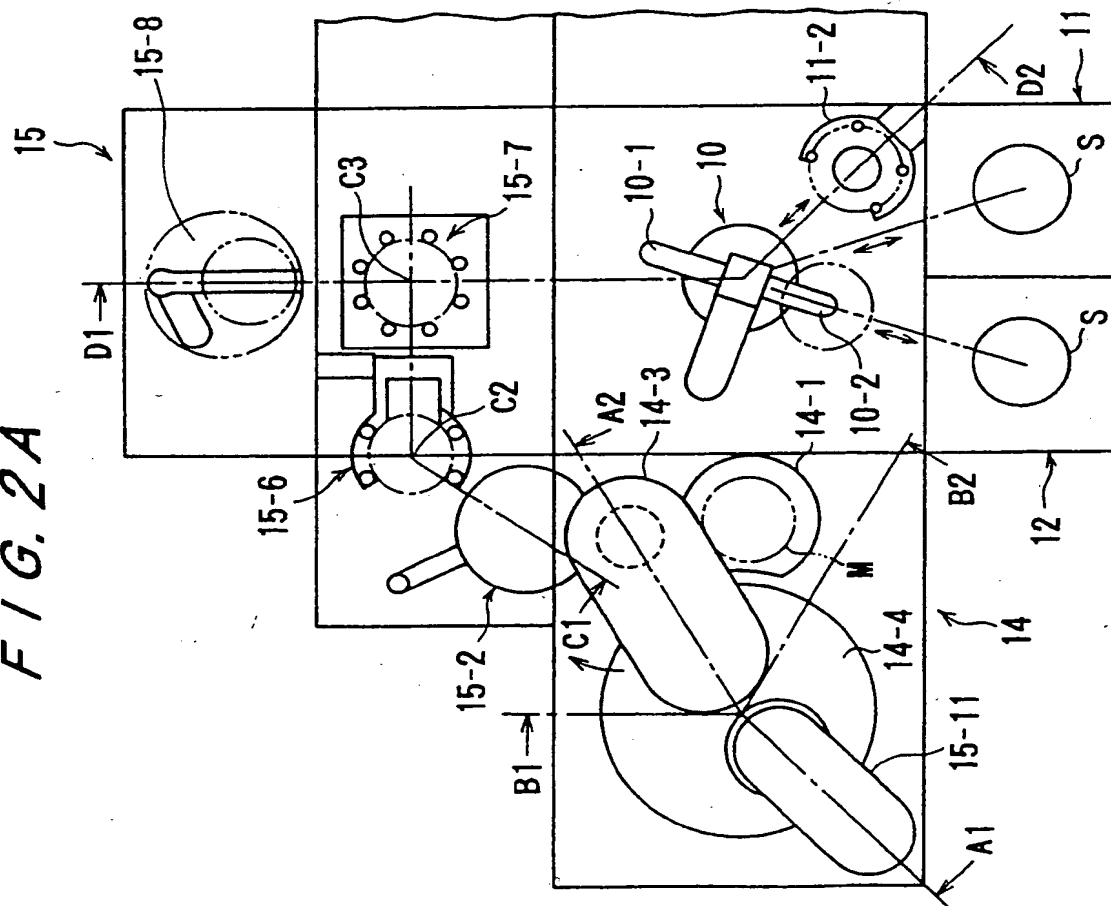
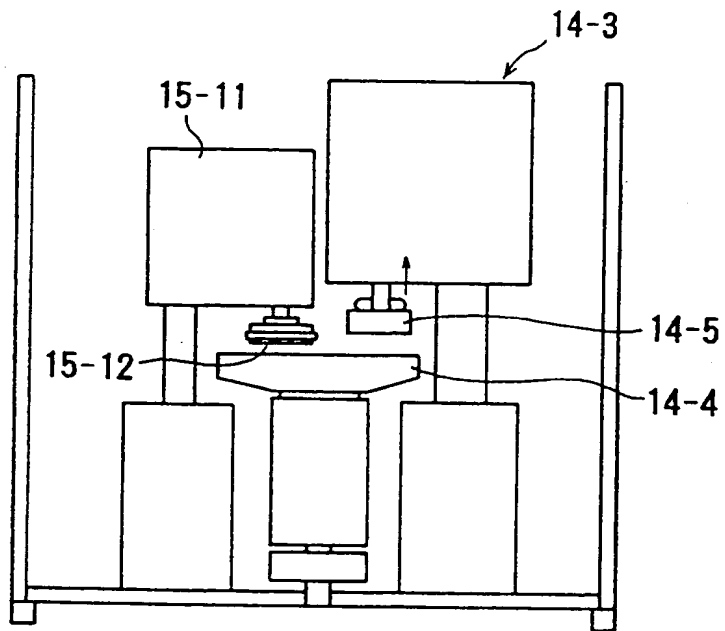


FIG. 2A



*FIG. 3*



*FIG. 4*

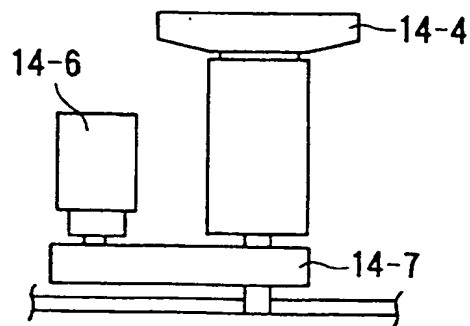


FIG. 5

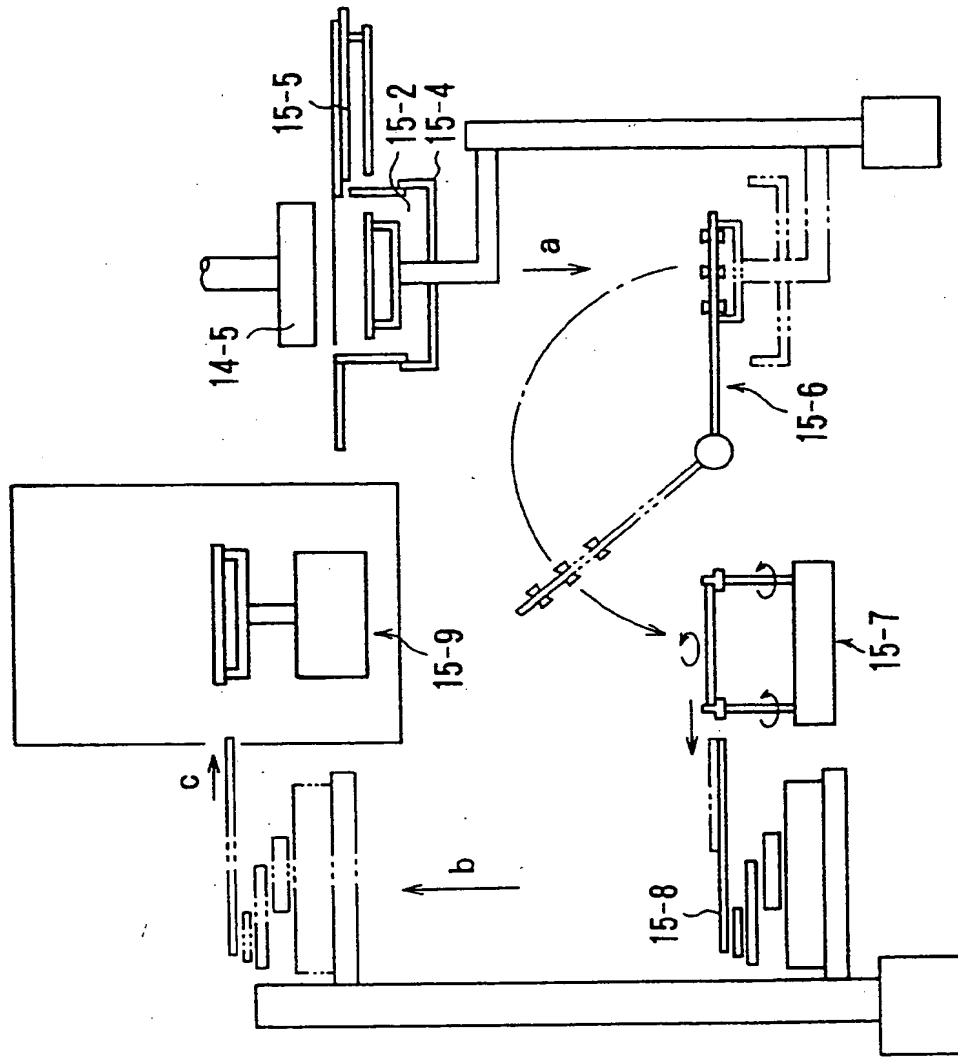




FIG. 6

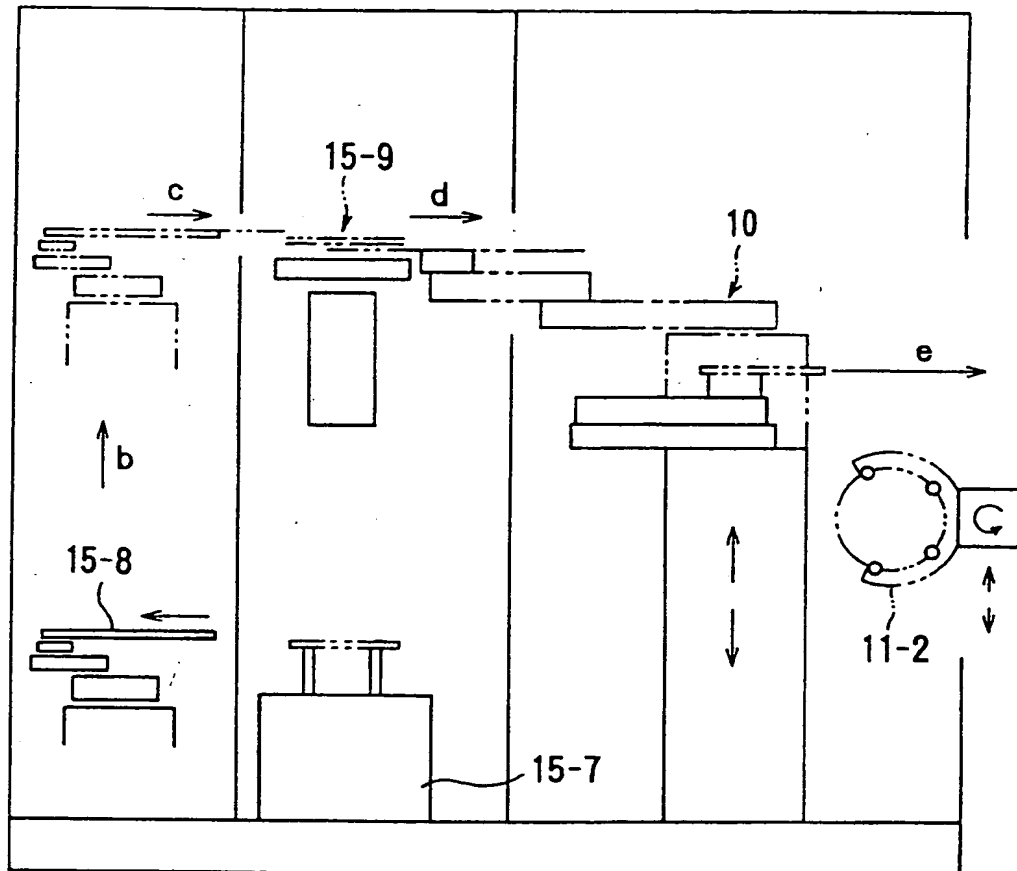


FIG. 7

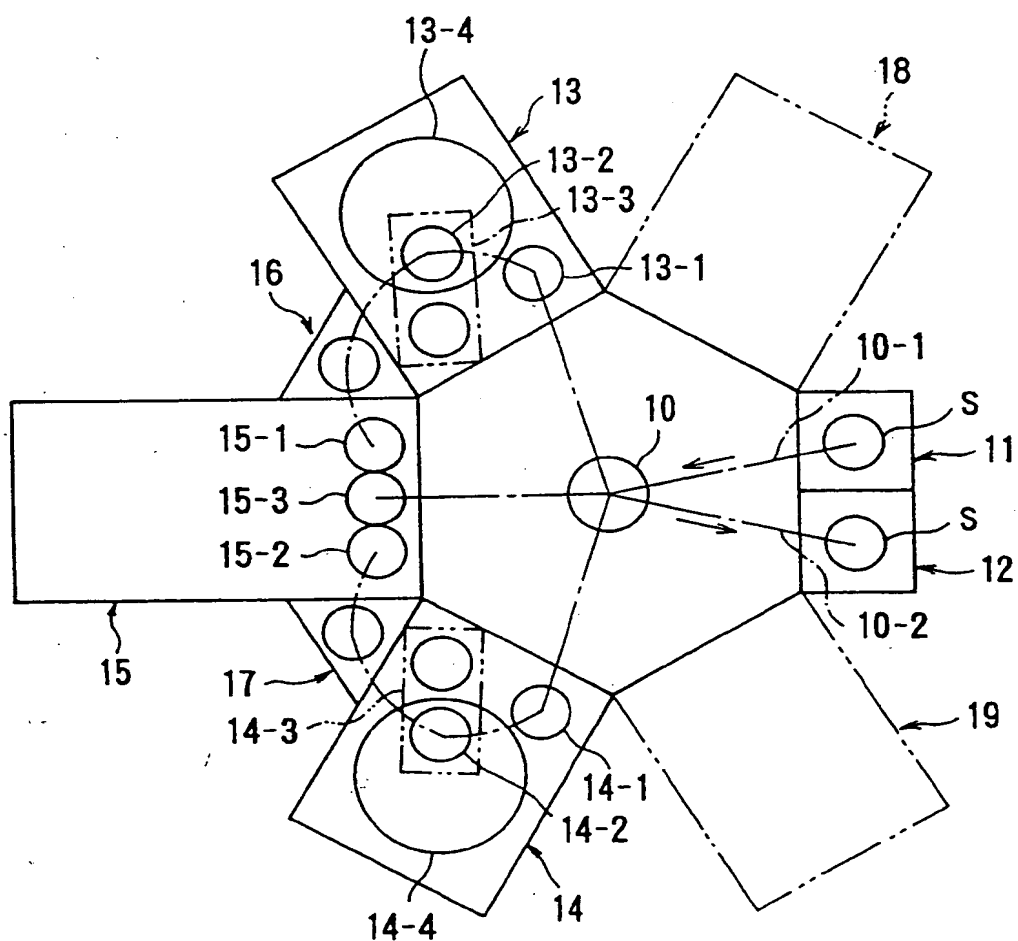
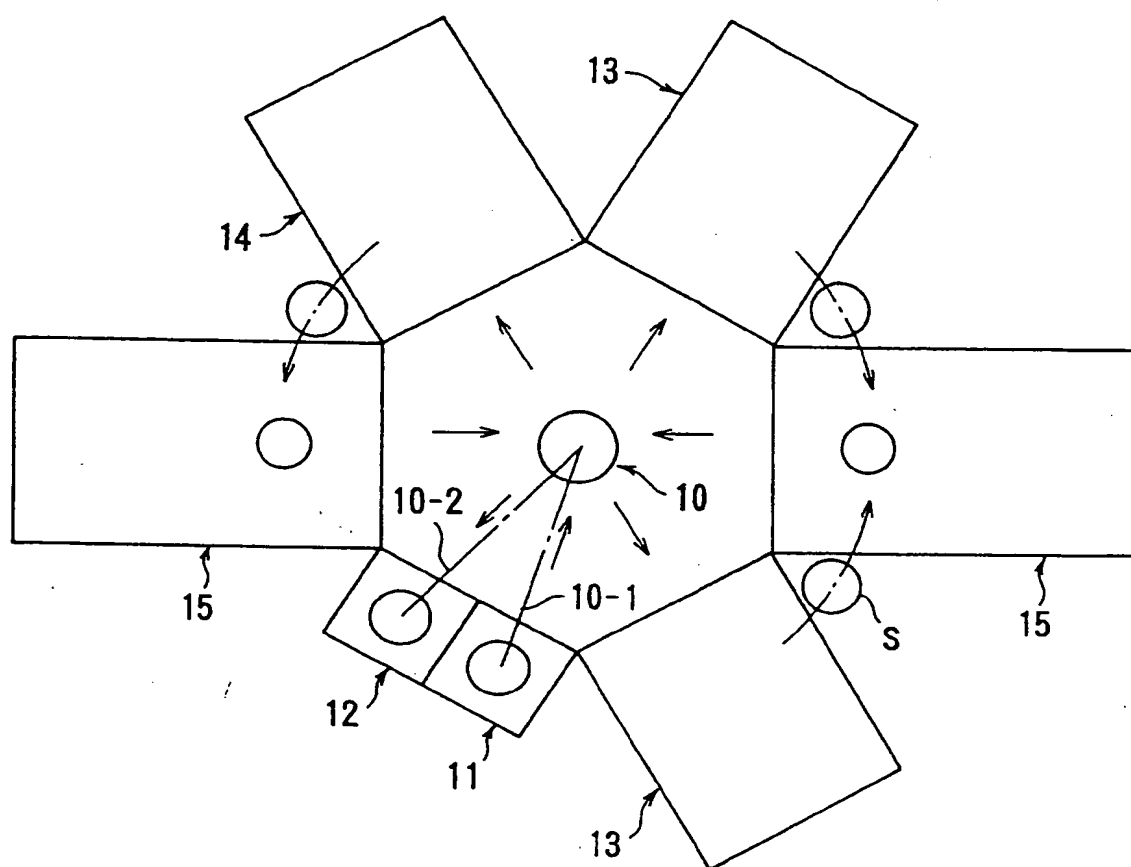


FIG. 8



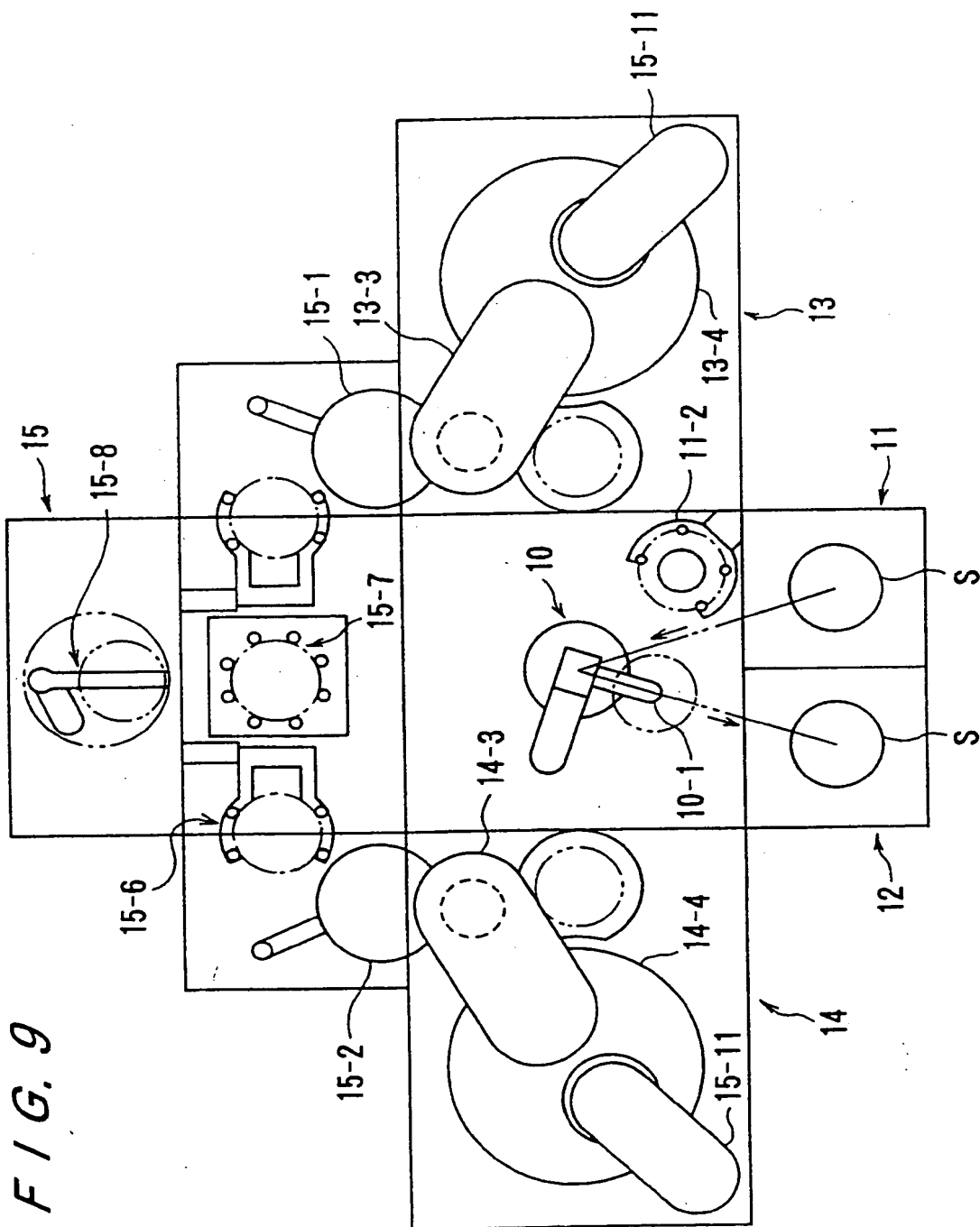


FIG. 10

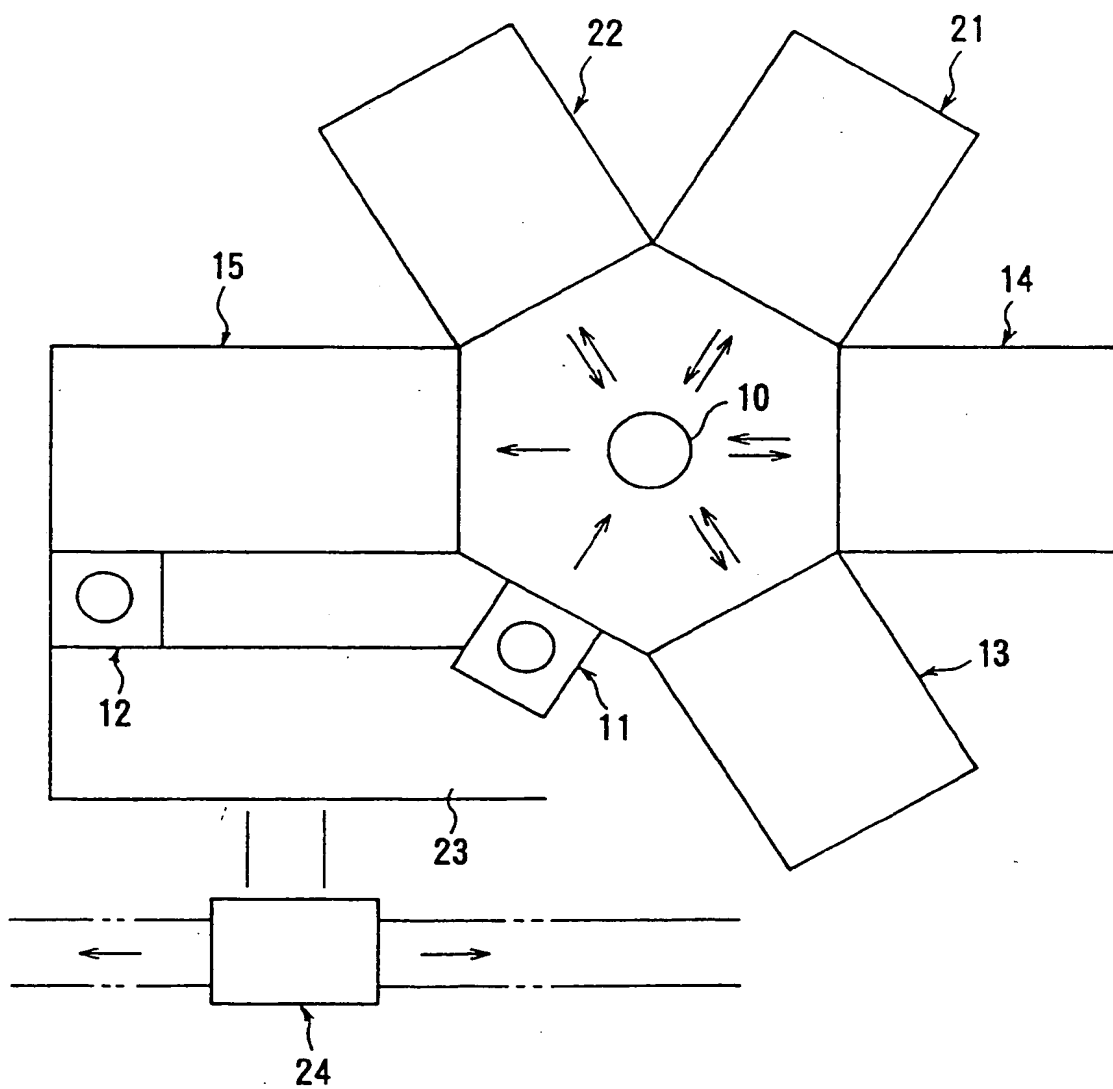
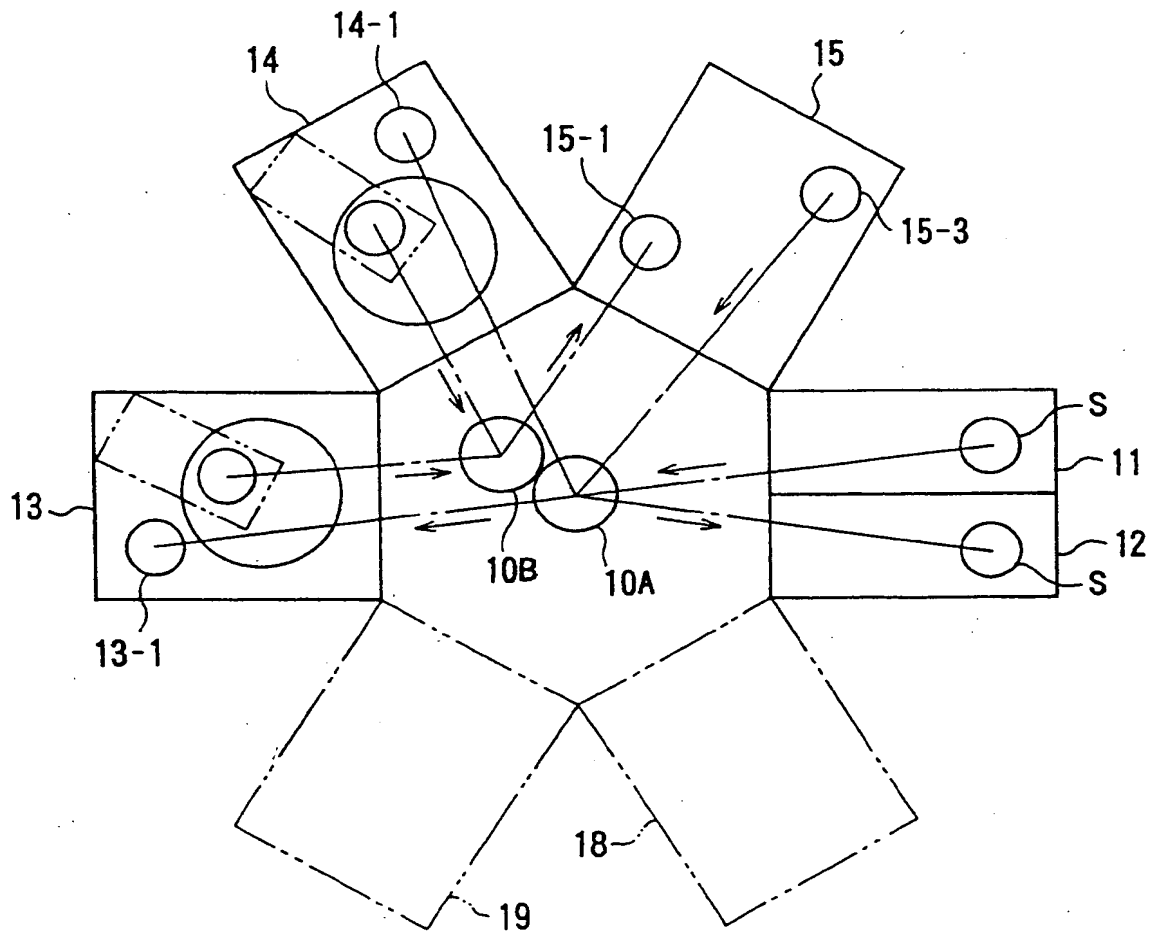


FIG. 11





European Patent  
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## EUROPEAN SEARCH REPORT

Application Number  
EP 94 11 4828

| DOCUMENTS CONSIDERED TO BE RELEVANT   |   |  |  |
|---|---|--|--|
| Category  | Citation of document with indication, where appropriate, of relevant passages   | Relevant to claim  | CLASSIFICATION OF THE APPLICATION (Int.Cl.6) |
| A   | US-A-4 653 231 (PAUL W. CRONKHITE ET AL.)<br>* the whole document *   | 1-12   | B24B37/04                                    |
| A   | ---<br>PATENT ABSTRACTS OF JAPAN<br>vol. 12, no. 485 (M-777) 19 December 1988<br>& JP-A-63 207 559 (DISCO ABRASIVE SYST LTD) 26 August 1988<br>* abstract * | 1,4,5,8,<br>9,11,12  |  |
| A   | ---<br>PATENT ABSTRACTS OF JAPAN<br>vol. 8, no. 80 (M-289) 12 April 1984<br>& JP-A-58 223 561 (DEISUKO : KK) 26 December 1983<br>* abstract *               | 1-7  |  |
|   |   |  | TECHNICAL FIELDS SEARCHED (Int.Cl.6)         |
|   |   |  | B24B   |
| The present search report has been drawn up for all claims  |   |  |  |
| Place of search<br>BERLIN   |   | Date of completion of the search<br>10 January 1995  | Examiner<br>Cuny, J-M                        |
| CATEGORY OF CITED DOCUMENTS   |   |  |  |
| X : particularly relevant if taken alone<br>Y : particularly relevant if combined with another document of the same category<br>A : technological background<br>O : non-written disclosure<br>P : intermediate document |   | T : theory or principle underlying the invention<br>E : earlier patent document, but published on, or after the filing date<br>D : document cited in the application<br>L : document cited for other reasons<br>& : member of the same patent family, corresponding document |  |

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